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New records of *Uredinales* from Fairy Meadows, Pakistan

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Abstract— *Puccinia pygmaea* var. *angusta* and *P. urticata* var. *urticata* were collected in Fairy Meadows and are new records for Pakistan. Similarly the aecidial stages of *Uromyces hedysari-obscuri* and *U. polygoni-avicularis* are an addition to the rust flora of this country. *Puccinia alpina, P. leveillei,* and *P. ribis* are redescribed and illustrated from Fairy Meadows.

Key words — *Bistorta vivipara*, Nanga Parbat

Introduction

Fairy Meadows in Northern Pakistan is a floristically rich area, from which about 70 species of rust fungi have been reported (Afshan et al. 2009). During several extensive surveys of the region, seven plants infected with rust fungi were collected. Among these, *Puccinia pygmaea* var. *angusta* on *Calamagrostis epigejos* and *P. urticata* var. *urticata* on *Carex flacca* are new records for Pakistan. The aecidial stages (I) of *Uromyces hedysari-obscuri* and *U. polygoni-avicularis* are also here described as an addition to the rust flora of Pakistan. *Puccinia alpina, P. leveillei,* and *P. ribis,* which represent new records for Fairy Meadows, are re-described to illustrate important morphological features using scanning electron microscopy.

Materials & methods

Freehand sections of infected tissue and spores were mounted in lactophenol and gently heated to boiling. The preparations were observed under a NIKON YS 100 microscope and photographed with a digipro-Labomed and JSM5910 scanning electron microscope. Drawings of spores and paraphyses were made using a Camera Lucida (Ernst Leitz Wetzlar, Germany). Spore dimensions were taken by an ocular micrometer. At least 25 spores were measured for each spore stage. Images were also obtained of the rust spores using a scanning electron microscope (SEM). The rusted specimens have been deposited in the herbarium of the Botany Department at the University of the Punjab, Lahore (LAH).

Taxonomy

Puccinia pygmaea* var. *angusta Cummins & H.C. Greene, Mycologia 58: 715 (1966). Fig. 1

Spermogonia and aecia not found. Uredinia amphigenous, mostly on adaxial surface, pale brown to golden brown, 0.09–0.3 × 0.1–0.4 mm. Urediniospores ellipsoid to broadly ellipsoid or ovoid, 21–25 × 25–29 µm; wall 1.5–2 µm thick, pale yellow to pale brown, echinulate; germ pores obscure, 4–6(–8), scattered. Paraphyses clavate to capitate, peripheral to intermixed, hyaline to pale brown, 14–18 µm wide, to 80 µm long. Telia amphigenous, covered by epidermis, dark brown to blackish brown, loculate, 0.09–0.4 × 0.2–0.6 mm. Teliospores 1–2 celled, clavate or ellipsoid; wall 1.5–2 µm thick, cinnamon brown to chestnut brown, smooth; 15–23 × 42–58 µm (mean 16.6 × 47.5 µm); apex mostly truncate, sometimes rounded to conical, 4–6(–7) µm thick; germ pore obscure; pedicel hyaline to pale brown, 5–7 × 8–15 µm, one-celled spores abundant.

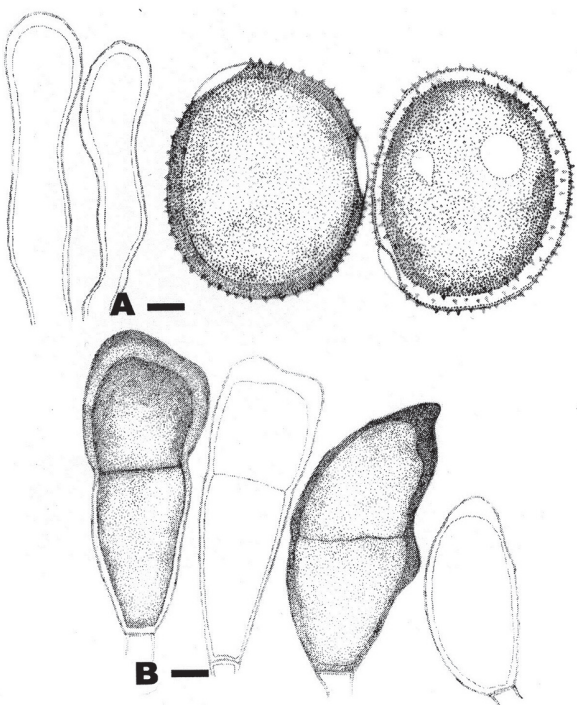

Fig. 1. Lucida drawings of *Puccinia pygmaea* var. *angusta*.
(A) Urediniospores and paraphyses. (B) 1–2 celled teliospores. Scale bar = 10 µm.

Material examined: On *Calamagrostis epigejos* (L.) Roth (*Poaceae*), with II and III stages, Pakistan, Northern Areas, Fairy Meadows, 3036 m, 12 Aug 2007, N.S.Afshan #G 90. (LAH Herbarium NSA 1083).

Comments: Six varieties of *P. pygmaea* are recognized based on spore size: *P. pygmaea* var. *ammophilina* (Mains) Cummins & H.C. Greene, *P. pygmaea* var. *angusta*, *P. pygmaea* var. *chisosana* Cummins, *P. pygmaea* var. *major* Cummins & H.C. Greene, *P. pygmaea* var. *minor* Cummins & H.C. Greene, and *P. pygmaea* Erikss. var. *pygmaea* (Cummins 1971).

Ahmad (1956a, b) reported *P. pygmaea* on *Agrostis munroana* Aitch. & Hemsl. from Kaghan valley, and Afshan & Khalid (2009) reported *P. pygmaea* var. *pygmaea* on *Agrostis gigantea* Roth from Bara Gali (NWFP). The variety *P. pygmaea* var. *angusta* is a new record for Pakistan.

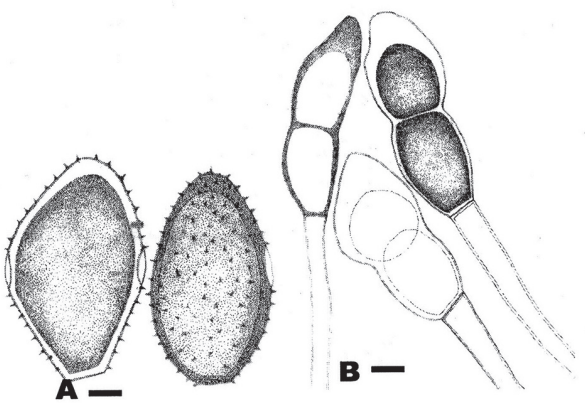

Fig. 2. Lucida drawings of *Puccinia urticata* var. *urticata*. (A) Urediniospores. (B) Teliospores. Scale bar = 10 µm.

Puccinia urticata F. Kern, Mycologia 9: 214 (1917) var. ***urticata*** Fig. 2

Spermogonia and aecia unknown. Uredinia mostly hypophyllous, sometimes amphigenous, on leaves and culms, intermixed with telia. Urediniospores ovoid to obovoid or ellipsoid to broadly ellipsoid, 18–24 × 23–31 µm (mean 22.0 × 27.6 µm); wall 1.5–2 µm thick, pale brown to cinnamon brown, finely and sparsely echinulate; germ pores 2–4, equatorial; pedicel hyaline, short. Telia mostly hypophyllous, rarely amphigenous, intermixed with uredinia, dark brown to blackish brown, covered by epidermis, 0.1–0.3 × 0.2–0.5 mm. Teliospores clavate to broadly clavate or oblong, not or slightly constricted at septum, 14–24 × (38–)42–71 µm (mean 19.2 × 52.5 µm); wall 2–3 µm thick, golden brown to chestnut brown, smooth; apex mostly rounded, 9–15 µm

thick; germ pores obscure; pedicel hyaline to pale brown, thin walled, 7–10 µm wide and up to 100 µm long.

Material examined: On *Carex flacca* Schreb. (*Cyperaceae*), with II and III stages, Pakistan, Northern Areas of Pakistan, Fairy meadows, 3036 m, 12 Aug 2007, N.S.Afshan #74. (LAH Herbarium NSA 1098).

Puccinia urticata var. *urticata* is a new record for Pakistan.

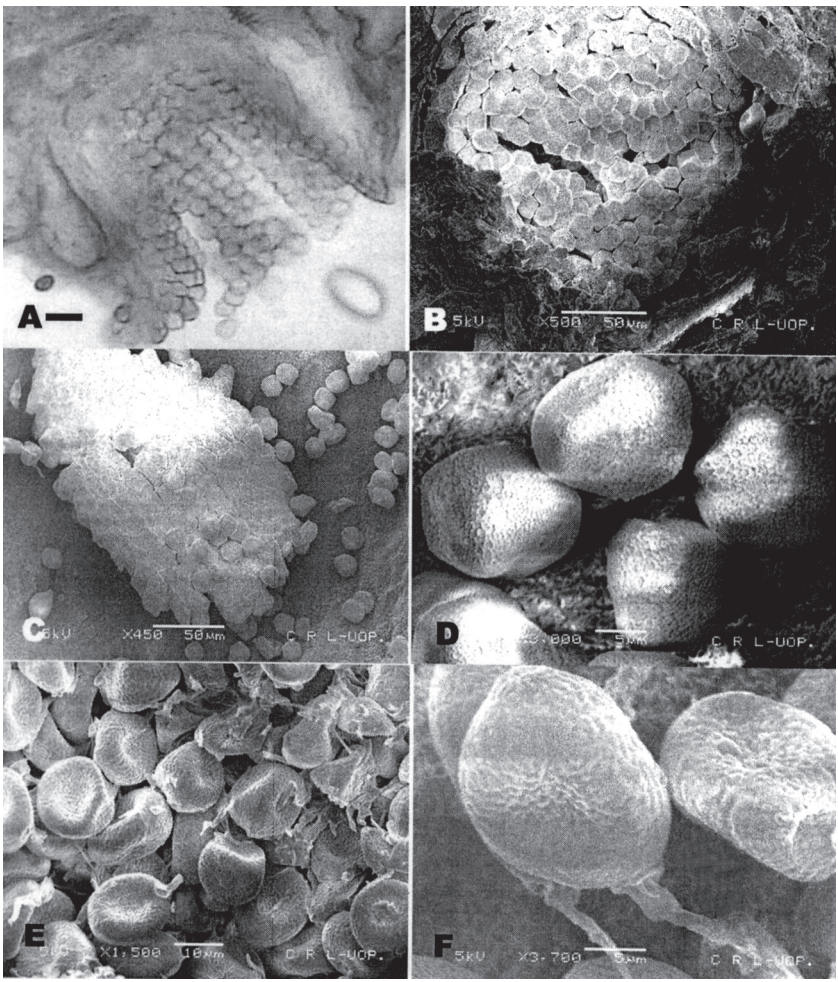

Fig. 3. *Uromyces hedysari-obscuri.* (A) Aecium containing aeciospores (B) SEM photograph of an aecium. (C) Aeciospores with peridial cells. (D) Aeciospores showing verrucose wall ornamentation. (E) SEM photograph of teliospores. (F) Teliospores showing verrucose wall ornamentation. Scale bar for E = 0.1 mm.

Uromyces hedysari-obscuri (DC.) Carestia & Picc., in Orbigny, Erb. critt. Ital., Ser. 2, 9: no. 447 (1871). Figs. 3–4

Spermogonia not known. Aecia mostly caulicolous, gregarious, in rounded groups. Aeciospores angular to globose, verrucose, hyaline with a yellowish tinge, 16–21 × 20–24 µm; peridial cells hyaline to pale yellow, angular to rectangular, verrucose, 20–24 × 23–31 µm. Telia amphigenous, mostly epiphyllous, scattered or gregarious, small, roundish, early naked, surrounded by a ruptured epidermis, dark brown to blackish brown. Teliospores globose, oblong or ellipsoid; 16–19 × 20–29 µm; apex rounded, with light colored papilla, 3–6 µm thick; wall 1.5–2.5 µm thick, dark brown to chestnut brown, verrucose; germ pores 2, equatorial; pedicel hyaline, short, deciduous, 6–7 × 14–16 µm.

Material examined: On *Hedysarum falconeri* Baker (*Fabaceae*), with I & III stages, Pakistan, Northern Areas, Fairy Meadows, 3036 m, 12^{h} Aug 2007. N.S.Afshan #G16. (LAH Herbarium NSA 1006).

The teliospore stage of *Uromyces hedysari-obscuri* has been reported on the same host from Fairy Meadows (Sultan 2005). The aecidial stage (I) of this fungus, which is described here for the first time from Pakistan, is an addition to our rust flora.

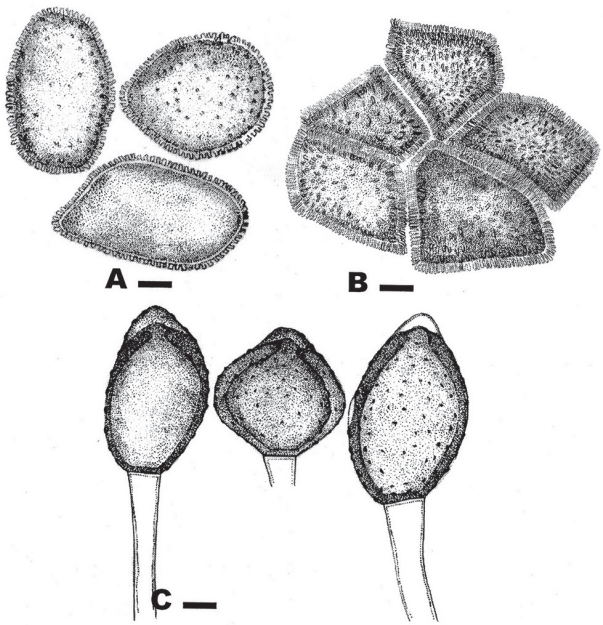

Fig. 4. Lucida drawings of *Uromyces hedysari-obscuri.*
(A) Aeciospores showing verrucose wall ornamentation. (B) Peridial cells.
(C) Teliospores showing verrucose wall ornamentation.
Scale bar for A = 5 µm, B & C = 10 µm.

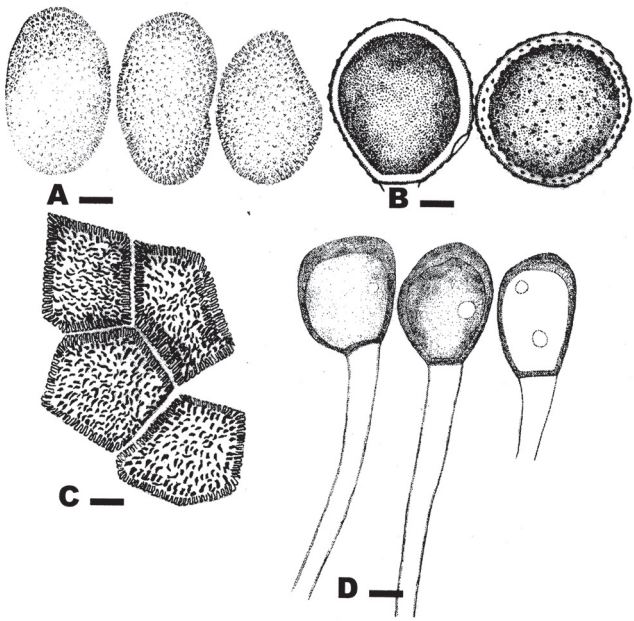

Fig. 5. Lucida drawings of *Uromyces polygoni-avicularis*.
(A) Peridial cells. (B) Aeciospores. (C) Urediniospores showing germ pores.
(D) Teliospores. Scale bar = 10 µm.

Uromyces polygoni-avicularis (Pers.) P. Karst., Bidr. Känn. Finl. Nat. Folk 4: 12 (1879), as '*polygoni avicularіae*'. Figs. 5–6

Aecia hypophyllous, minute, in circular or irregular shaped groups, orange, cupulate. Aeciospores globose to ellipsoid, verrucose, hyaline to yellow with orange granules, 15–22 × 18–24 µm; peridial cells rhomboid, hyaline to pale yellow, striate, verrucose, 17–24 × 23–29 µm. Uredinia amphigenous, scattered or gregarious, minute, roundish, brown to cinnamon brown, 0.09–0.3 × 0.2–0.8 mm. Urediniospores globose to subglobose or ellipsoid, 18–24 × 20–29 µm; wall 1.5–3.0 µm thick, golden brown to cinnamon brown, verruculose; germ pores 2–4, equatorial. Telia amphigenous, small, scattered or gregarious, on leaves and stem, roundish or oblong, blackish brown, 0.1–0.5 × 0.2–0.8 mm. Teliospores subglobose, ovate or ellipsoid, 18–24 × 22–31(–35) µm; apex rounded or truncate, 4–6 µm thick; wall 2–3 µm thick, smooth, golden brown to chestnut brown; germ pore, apical or sub-apical; pedicel hyaline to pale yellow, persistent, 8–10 × 90–104 µm.

Material examined: On *Bistorta vivipara* (L.) Delarbre (*Polygonaceae*), with II & III stages, Pakistan, Northern Areas, Bial camp (Nanga Parbat base camp), 11 Aug 2007. N.S.Afshan #G10. (LAH Herbarium NSA 1008). On *Polygonum aviculare* L.

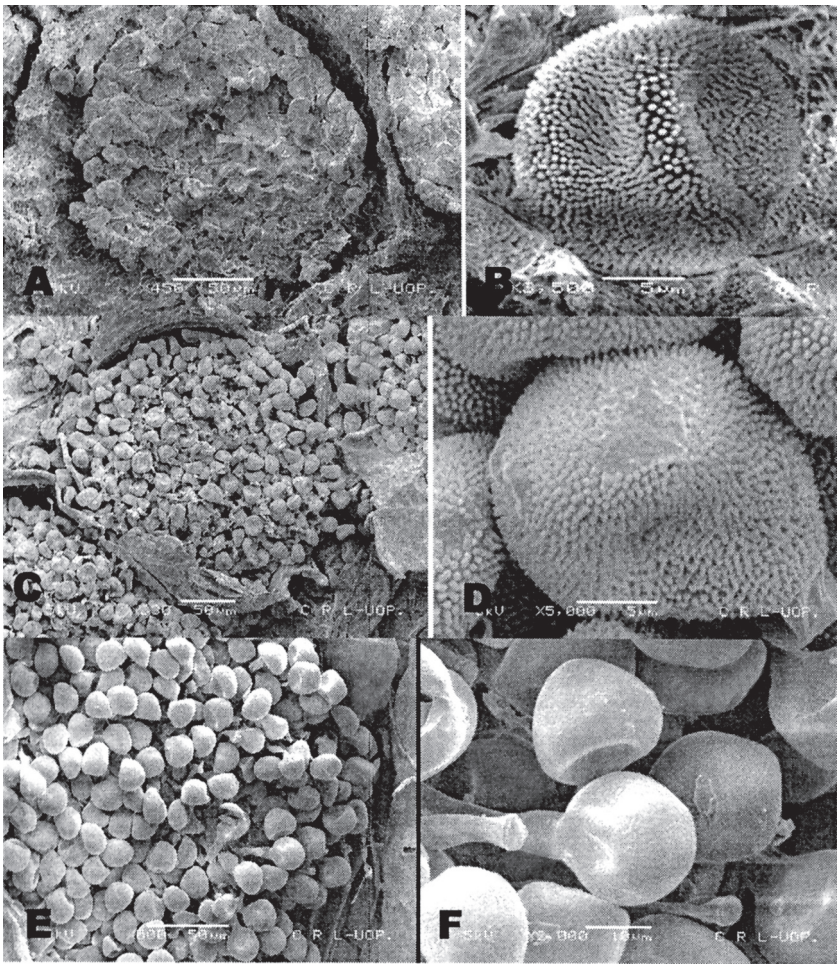

Fig. 6. *Uromyces polygoni-avicularis.* (A) SEM photograph of an aecium. (B) An aeciospore showing verrucose wall ornamentation. (C) SEM photograph of a uredinial sorus. (D) SEM photograph of a urediniospore showing verrucose wall ornamentation. (E) SEM photograph of a telium containing teliospores. (F) Teliospores.

(*Polygonaceae*), with I & III stages, Pakistan, Northern Areas, Fairy Meadows, 3036 m, 12 Aug 2007. N.S.Afshan #G02. (LAH Herbarium NSA 1007)

The uredinial and telial stages of *Uromyces polygoni-avicularis* were previously reported on *Polygonum aviculare* from Kaghan and Quetta valleys and on *Bistorta vivipara* (as *P. viviparum* L.) from Hazara, Madian, and Swat (Ahmad et al. 1997). The aecidial stage represents a new record for Pakistan

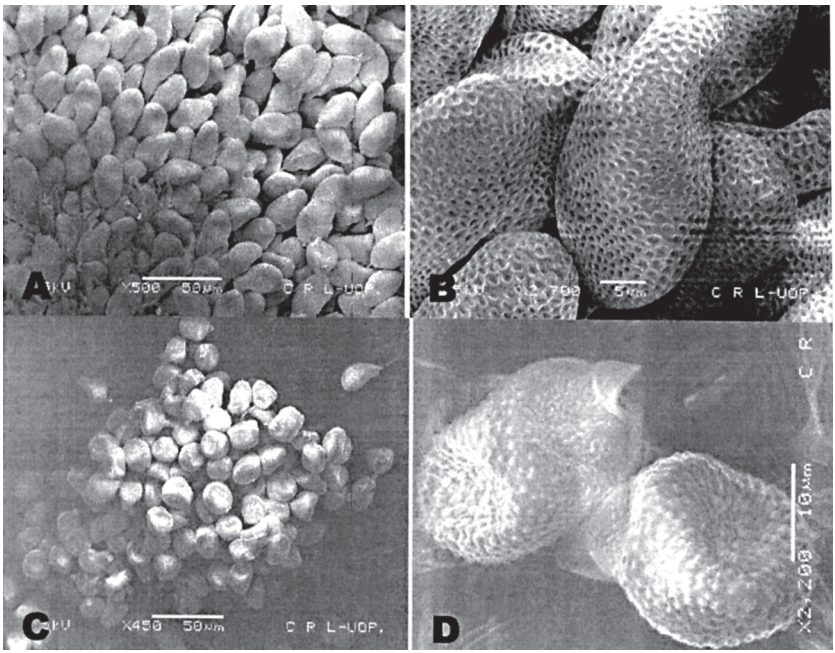

Fig. 7. A–B. *Puccinia alpina*. (A) SEM photograph of telium showing teliospores. (B) Teliospores showing striately verrucose wall ornamentation. C–D: *Puccinia leveillei*. (C) SEM photograph of a telium (D) Teliospores showing verrucose wall ornamentation.

Puccinia alpina Fuckel, Jahrb. Nassauischen Vereins Naturk. 27–28: 13 (1873).
Fig. 7A–B, 8A

Spermogonia, aecia and uredinia unknown. Telia hypophyllous, scattered or loosely clustered, small roundish, soon naked, pulvinate, dark brown to blackish brown, 0.08–0.1 × 0.2–0.8 mm. Teliospores ellipsoid to oblong or clavate, rounded at both ends or sometimes attenuated downwards, not or slightly constricted at septum, base roundish or narrowed, 16–26 × (25–)31–50 µm; wall 1.5–2 µm thick, verrucose, golden brown to chestnut brown; apex 3–5 µm thick, pale in color; germ pore 1 per cell, germ pore of both cells near septum or sometimes apical cell, with hyaline umbo over each pore; pedicel hyaline, deciduous, up to 25 µm long and 5–6 µm wide.

Material examined: On *Viola biflora* L. (*Violaceae*), with III stage, Pakistan, Northern Areas, Fairy Meadows, 3036 m, 12 Aug 2007. N.S.Afshan #G 08. (LAH Herbarium NSA 1005).

Ono (1992) previously reported *Puccinia alpina* on *Viola rupestris* F.W. Schmidt from Kaghan valley. The above collection is a new record for Fairy Meadows.

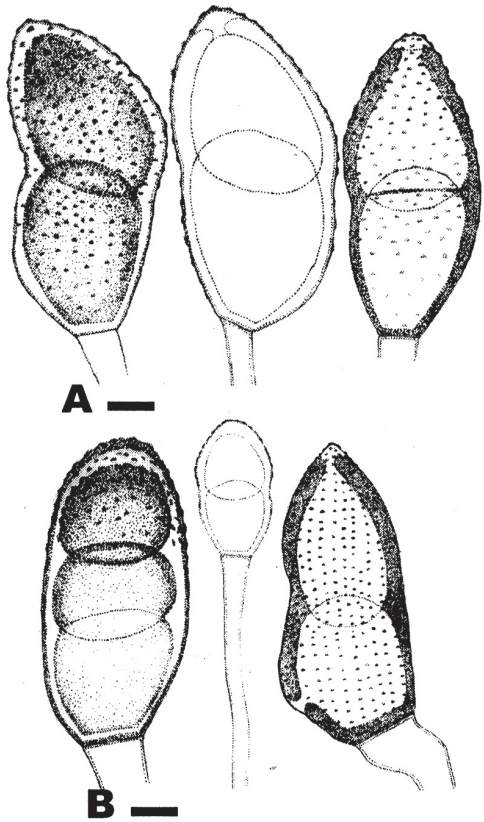

Fig. 8. (A) Lucida drawing of teliospores of *Puccinia alpina*.
(B) Lucida drawing of teliospores of *Puccinia leveillei*.
Scale bars = 10 μm.

Puccinia leveillei Mont., in Gay, Hist. Fis. Polit. Chile 8: 41 (1852). Fig. 7C–D, 8B
= *P. geranii-sylvatici* P. Karst., Enum. Fung. Lapponia: 220 (1866).

Spermogonia, aecia and uredinia unknown. Telia mostly amphigenous, 0.2–0.4 × 0.2–0.6 mm, dark brown. Teliospores mostly two-celled, sometimes three-celled; ellipsoid to clavate, not or slightly constricted at septa, 14–23 × 30–44(–47) μm; wall 2–3 μm thick, densely verrucose, brown to chestnut brown; apex rounded or truncate, 4–5 μm thick; germ pore of upper cell mostly apical, sometimes sub-apical, of lower cell near pedicel; pedicel short, hyaline, 8–9 × 10–15 μm.

Material examined: On *Geranium sibiricum* L. (*Geraniaceae*), with III stage, Pakistan, Northern Areas, Fairy Meadows, Bial camp (Nanga Parbat base camp) 3036 m, 12 Aug 2007. N.S.Afshan # G13. (LAH Herbarium NSA 1010).

Ahmad 1956a reported *P. leveillei* on *Geranium pratense* L., *G. collinum* Stephan ex Willd., *G. rectum* Trautv., and *G. eglandulosum* Dalla Torre from Kaghan, Kalam, Baltistan, and Barum valleys. This above collection represents a new record from Fairy Meadows (Bial camp); *Geranium sibiricum* is a new host species in Pakistan.

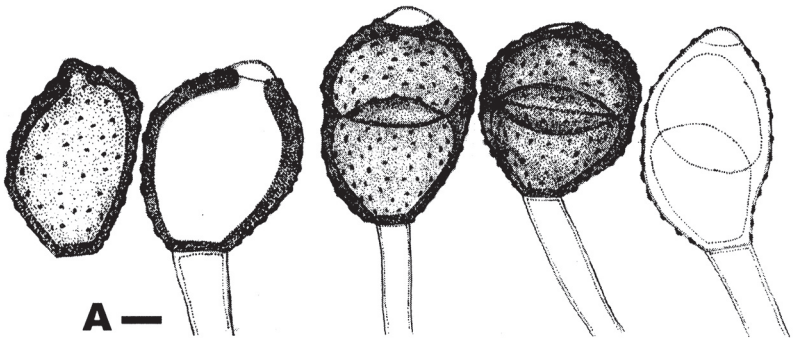

Fig. 9. Lucida drawing of *Puccinia ribis*.
1–2 celled teliospores showing verrucose wall ornamentation. Scale bar = 10 µm.

Puccinia ribis DC., Fl. franç., 3e Ed., 2: 221 (1805). Fig. 9

Spermogonia unknown, aecia and uredinia absent. Telia epiphyllous, surrounded by a discolored yellow zone, circinate, pulverulent, 0.9–3 × 3–5 mm, chestnut brown. Teliospores ovoid or oblong to ellipsoid, rounded above and below, hardly constricted, 15–24 × 20–35 µm; wall 1.5–2.5 µm thick at sides and 4–5 µm thick at apex, verrucose, chestnut brown; germ pores 1 per cell, apical in upper cell with a hyaline papilla, pore of lower cell usually basal; pedicels hyaline, deciduous, 4–5 × 18–25 µm. A few one-celled spores also observed.

Material examined: On *Ribes nigrum* L. (*Grossulariaceae*), with III stage, Pakistan, Northern Areas, Fairy Meadows, 3036 m, 12th Aug 2007. N.S. Afshan # G14. (LAH Herbarium NSA 1011).

Ahmad 1956a reported *P. ribis* on *Ribes rubrum* L. from Swat, Kalam, and Hazara. Our collection represents a new record from Fairy Meadows.

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